A Geostatistical Analysis of the Major Controlling Factors Affecting Stream Geochemistry in Taylor Valley, Antarctica

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1. Introduction

In Taylor Valley, Antarctica, there are three closed-basin lakes that each have different chemistries. One lake is fresh (Lake Hoare), one is brackish (Lake Fryxell), and the other is hyper-saline (Lake Bonney). The fact that these ice-covered lakes are of various ages and have been subjected to different histories, supports their chemical diversity. This study focused on another contributing factor to differences in lake chemistry, which is the source of the solutes from the streams. The streams come from glacial meltwater. These freshwater streams accumulate and transport ions, nutrients, and biomass as they flow during the austral summer. This creates a certain "fingerprint" for each stream. The goal of this study was to discern between the stream chemistry variance and find trends associated with these differences. I expected to see an east-west trend because the eastern side of Taylor Valley has younger soils. To demonstrate my results, I used chloride, alkalinity, nitrate and soluble reactive phosphorus (SRP). Chloride is an excellent tracer because it is conservative. Alkalinity represents weathering of carbonates and silicates. N and P are essential nutrients for plant life and assist in explaining the algal mat distribution. Landscape position and age, the presence and absence of algal mats, and stream length had most significant impact on stream chemistry.

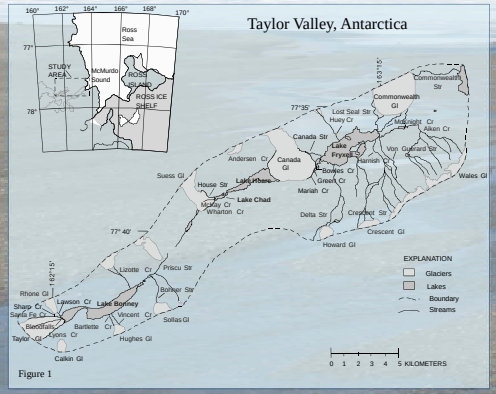


Figure 1

2. Method

Stream chemistry data from Taylor Valley, Antarctica has been collected since 1993 (Figure 1). Within each year, samples were collected from November through January. This is the only period of time in which the glaciers produce meltwater to create streams. The statistical methods used were Analysis of Variance (ANOVA), Principle Component Analysis (PCA), and linear regression. To conduct these analyses, I used XLStat Pro.


Photo credit: Kathy Welch

3. Results/Discussion

Using PCA, 92.6% of the chemical variance in all the stream data can be attributed to four significant factors:

- 51.3% – Location
- 19.1% – Weathering
- 16.4% – Biomass
- 5.8% – Hyporheic zone exchange

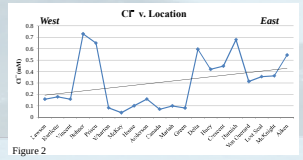
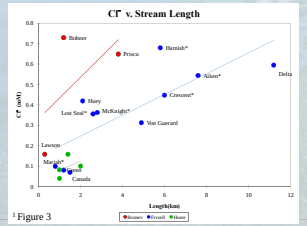


Figure 2

- Chloride is increasing to the east
- Indicates more salt dissolution in eastern streams
- Marine aerosol from the Ross Sea in the east contributes more salt
- The outliers are due to factors such as length (Delta), high gradient (Bohner), and the presence of ponds (Harnish and Aiken)



[1] Figure 3

- Cl^- concentrations increase with stream length
- Suggests evapoconcentration

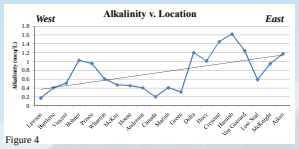


Figure 4

- Alkalinity increases to the east
- Indicates more weathering of carbonates and silicates on the eastern side of Taylor Valley


Photo credit: Chris Gardner

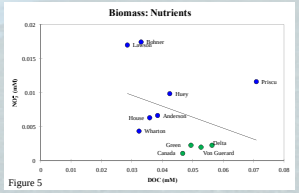


Figure 5

- Biomass abundant in Green, Canada, Delta, and Von Guerard
- As Dissolved Organic Carbon (DOC) increases, NO_3^- decreases
- Suggests biological uptake of nitrate and DOC loss from biomass

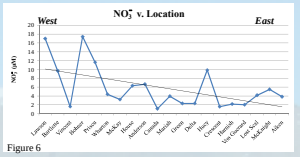


Figure 6

- Nitrate decreases to the east with the highest concentrations in the oldest landscape (Figure 8)
- Less nitrate indicates more biomass presence
- Biomass is more abundant in the east

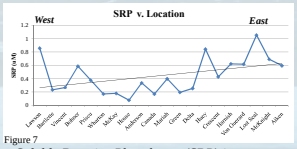
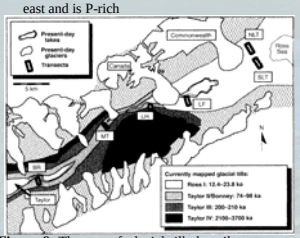


Figure 7

- Soluble Reactive Phosphorus (SRP) increases to the east
- Younger soils exist in the east
- The volcanic rock, Kenyite, is present in the east and is P-rich



[2] **Figure 8.** The age of glacial tills heavily corresponds to the relationship of nitrogen and phosphorus. The N:P ratio is 16:1. Since the west has older soils, N has accumulated over time by atmospheric deposition and P has been weathered from the soils. The east is from younger rocks, where there is more P available, thus N is limiting.

4. Conclusions

The stream chemistry in Taylor Valley, Antarctica strongly reflects landscape position, landscape age, stream length, and biomass occurrence. Some streams look like outliers, but there are other minor factors that contribute to a stream's individuality. High gradient in Bohner Stream promotes more salt dissolution and weathering (Figures 2 and 4). Intermittent ponds within Harnish and Aiken Streams allow the streams to become more Cl^- concentrated, showing an increase in salt dissolution (Figure 2). Priscu is the only second ordered stream, meaning it has tributaries from the north and south side of the valley that contribute to high salt dissolution. The use of statistics in this study revealed each stream's signature which proved to be systematic.

Acknowledgements

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References

Stream chemistry data provided by www.mcmlter.org

[1] Alger et al, 1997, Ecological Processes in a Cold Desert Ecosystem: The Abundance and Species Distribution of Algal Mats in Glacial Meltwater Streams in Taylor Valley, Antarctica, *Occasional Paper*, v. 51, p. 20.

[2] Burkins et al, 2000, Origin and Distribution of Soil Organic Matter in Taylor Valley, Antarctica, *Ecology*, v. 81, p. 2379.